Do children benefit from increasing cigarette taxes? Accounting for the endogeneity of lung health and environmental tobacco exposure

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Introduction

Childhood exposure to environmental tobacco smoke is associated with reduced lung function and greater incidence of respiratory illness such as wheeze and chronic bronchitis. The correlation of ETS exposure and poor health outcomes has largely been considered evidence of causality, however, given the non-experimental design of much of the data, ETS exposure cannot be considered random. Therefore, unobservable factors may exist that influence a child's health and also his or her likelihood and level of exposure to ETS. My research employs an instrumental variables (IV) technique to overcome omitted-variable bias created in the health production function when exposure in nonrandom. Using the Third National Health and Nutrition Examination Survey, I use state level variation in cigarette taxes to estimate ETS exposure. Using estimated exposure, I develop consistent estimates of exposure's effect on children's lung function.

Background

There is no lack of research on the effects of environmental tobacco smoke (ETS), particularly with respect to the health of children. The California Environmental Protection Agency reports "The scientific and medical literature contains hundreds of investigations of the association between ETS exposures and a variety of adverse health impacts…" (Tobacco Control, 1997). As a result of the extensive body of literature, it is widely recognized that ETS exposure in early life contributes significantly to childhood morbidity. The evidence from the literature suggests that ETS exposure in early life puts children at greater risk of developing respiratory ailments such as asthma and chronic bronchitis. ETS diminishes lung function and lowers respiratory functionality. ETS has been further implicated as a public health risk by evidence that shows it is associated with higher rates of SIDS, middle ear infection, and even dental caries.

Data

The data come from the Third National Health and Nutrition Examination Survey, 1988-1994. The sample consists of non-smoking children 8-16 years of age. Table 1 presents a summary of selected statistics. The measure of ETS exposure is serum cotinine, a biomarker of a nicotine metabolite. I employ four primary health outcome measure, based on spirometric tests administered to the sample. Low age/sex/anthropometric adjusted test results indicate lung obstruction or restriction.

Table 1: Summary Statistics

Variable	Definition	Mean	S.D.
Demographic Characteristics			
Analytic sample N=3,435			
Age	Average age	11.9	2.51
Female	0-1 indicator for female	0.485	0.499
Non-white	0-1 indicator for non-white	0.219	0.140
HH head education	HH head's highest year of schooling	12.5	3.21
Any household smokers	0-1 indicator for any HH smoker	0.363	0.481
Serum cotinine level	Average serum cotinine level, ng/ml	1.59	6.07
Health outcomes			
FEV_0.5 (ml)	Forced Expiratory volume in 0.5 seconds	2011.6	609.5
FEV_1	Forced Expiratory volume in 1 second	2618.9	827.7
FVC_max	Maximum Forced vital capacity	3028.2	973.1
FEF_75	Mid-flow forced expiratory volume	1351.0	621.01

* Unadjusted for anthropometric factors
Source: NHANES III 1988-1994

Instrumental Variables (IV)

The challenge of using an IV estimator is finding an appropriate instrument. The ideal candidate is a variable that is correlated with the endogenous variable, cotinine, the measure of *ETS exposure*, but uncorrelated with unobservable factors that influence exposure or lung function. An often used instrument in economics is a tax because is fulfills those requirements. Cigarette taxes influence exposure through their effect on cigarette consumption, the producer of ETS. I use the state level variation in cigarette taxes over a 7 years period to estimate ETS exposure. Table 2 shows that for a one percent increase in excise tax, ETS exposure to children decreases between .34% and .94 %.

Table 2: The impact of taxes on ETS exposure

Dependent variable[1]	Independent Variable[2]		(1)	(2)
Cotinine	Cigarette tax$_t$	β	-0.349**	-0.936*
			(0.115)	(0.453)
		R^2	0.119	0.13
Cotinine	Cigarette tax$_{t-1}$	β	-0.342**	-0.672**
			(0.116)	(0.138)
		R^2	0.118	0.201
State and year fixed effects			No	yes

NOTE: Standard errors, clustered by state, are in parentheses. * Indicates significance at the 5% level; ** Indicates significance at the 1% level. Models (1) and (2) contain covariates for age, sex, race, metropolitan location indicator, household income and household head's education level. Model (2) adds state and year fixed effects.
1. Serum cotinine level is measured in nanograms per milliliter (ng/ml) and is log transformed.
2. Cigarette tax is combined state and federal taxes and is log transformed.

Model

Equations (1) and (2) describe the process of estimating the effect of exposure on lung function.

$$(1) \quad Y_{irt} = \alpha_n + X_{irt}\beta_1 + E_{irt}\delta_1 + \varphi_{1r} + \upsilon_{1t} + \varepsilon_{irt}$$

$$(2) \quad E_{irt} = \alpha_i + X_{irt}\beta_2 + Z_{rt}\delta_2 + \varphi_{2r} + \upsilon_{2t} + u_{irt}$$

Equation (1) is the represents the production of lung health. Y is lung function of child i, in state r, at time t. In equation (2) the dependent variable is serum cotinine, bounded between .035 and 120 ng/ml. X is a set of controls for demographic characteristics, Z is cigarette tax of state r at time t. I control for state and year fixed effects with φ and υ. The results of the IV regressions are presented in Table 3.

Results

Table (3) presents the results of IV regressions for four spirometric measures.

Table 3.: Estimates of the Effect of ETS Exposure on Lung Function

Dependent variable	2SLS		LIML	
	(1)	(2)	(1)	(2)
FEV_0.5	-0.037**	0.043	-0.01**	-0.008**
	(0.012)	(0.012)	(0.012)	(0.012)
FEV_1	-0.039**	0.015	-0.0058**	-0.0062**
	(0.012)	(0.012)	(0.012)	(0.012)
FVC_max	-0.012**	-0.022**	-0.0029	-0.0021
	(0.012)	(0.012)	(0.012)	(0.012)
FEF25%-75%	0.0043	-0.095**	-0.0029**	-0.0022
	(0.012)	(0.012)	(0.012)	(0.012)
Instrument	Cig. tax$_t$	Cig. tax$_t$	Cig. tax$_t$	Cig. tax$_t$
State fixed Effects?	No	Yes	No	Yes
Year Fixed effects?	Yes	Yes	Yes	Yes
Instrument Diagnostics				
Partial R2	0.015	0.012		
Partial F-statistic	6.71	4.28		
N=3,435				

NOTE: Standard errors, clustered by state, are in parentheses. * Indicates the difference is significant at the 5% level; ** Indicates the difference is significant at the 1% level. FEV$_{.5}$ is forced expiratory volume in 0.5 seconds, maximum ml. FEV$_1$ is forced expiratory volume in 1 second, maximum ml. FVC$_{max}$ is maximum forced vital capacity, ml. FEF$_{25-75\%}$ is forced expiratory volume between 25% and 75% of maximum forced vital capacity, ml. All models contain covariates for age, sex, race, household income, metropolitan location indicator, household head's education level, body mass index, and sitting height. I perform an overidentification test by regressing the 2SLS residuals on the instruments and all exogenous variables in the model. The test statistic is computed as n×R^2 and has a χ^2(2) distribution. The overidentifying restrictions cannot be rejected in the case of FEV$_{0.5}$, FEV$_1$, and FVC$_{max}$ for the model without year and state effects (p-values=0.20, 0.25, 0.25). When year and state effects are included in the model, the restrictions cannot be rejected for FEV$_1$ and FVC$_{max}$ (p-values=0.25, 0.13).

Conclusions

The innovation of this study is the employment of an iv technique. Unobserved variables make coefficients in single stage OLS regression biased. Using state level variation in cigarette taxes, I am able to predict exposure in non-experimental data and estimate the effect of ETS exposure on lung function. My research is the first to show ETS is sensitive to taxes. The statistically significant does-response relationship of lung function ranges from 0.008 to 0.18% for every percent increase in exposure. For the widely used measure of lung obstruction, FEV1, or forced expiratory volume measured in the 1st second of breath, I find that having one smoker in the household reduces lung function by 1.8%, and a second smoker increases the deficit to 4.6%.

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